








# “The impact of financial digitalization on ensuring the economic security of a country at war: New measurement vectors”

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# THE IMPACT OF FINANCIAL DIGITALIZATION ON ENSURING THE ECONOMIC SECURITY OF A COUNTRY AT WAR: NEW MEASUREMENT VECTORS

## Abstract

The military actions in Ukraine have actualized the transformation and revision of existing approaches to assessing the country's economic security. Financial security, which is considered in this paper through its standard components such as financial sector security, stock market security, debt and budget security, has a significant effect on the formation of economic security. At the same time, digitalization in the financial sector was identified as a new component that provides access to financial resources even in the context of the deployment of hostilities in Ukraine. Therefore, this study assessed the effect of the state of financial security, taking into account the importance of financial digitalization for the economic security of Ukraine.

Based on quarterly data for the period 2015–2021, 42 indicators were analyzed, which were grouped according to the relevant components of financial security, and their integral indicators were determined using the Harrington method. A factor analysis of the formation of economic security was carried out using the principal components analysis, and an integral indicator of a country's economic security was calculated based on the Kinney multiplicative convolution. The integral indicator of economic security for 2025–2021 doubled and amounted to 0.63 units, which was due to the increased influence of financial digitalization processes, all other components either slowly decreased or were stable. Thus, the reserve of economic security that was formed during this period, including due to the intensive digitalization of the financial sector, allowed Ukraine to survive the first weeks of the war and ensure the functioning of the financial system.

## Keywords

financial sector, stock market, public debt, public budget,  
integral indicator, normalization, Harrington's method

## JEL Classification

F52, G17

## INTRODUCTION

Currently, both social and economic life in Ukraine is undergoing the most difficult period of its development. The military actions unleashed by Russia on the entire territory of Ukraine destroyed all traditional approaches to state management of financial and economic processes. The logistics, production and financial infrastructure established during thirty years of independence is completely deformed. Export-import flows are carried out exclusively through the western border of the country, temporarily losing control over the most essential sea channel for product sales. Migration processes have also acquired radically new aspects: it is not traditional seasonal workers who leave, but women with children.

At the same time, it should be noted that the financial architecture existing until February 24, 2022 has withstood most of the shocks caused by military events. Thus, during the first months of the Russian-

Ukrainian war, the population on the territories that were under partial occupation had an opportunity to pay for goods and services electronically, withdraw cash from ATMs, receive state assistance in case of job loss, etc. In addition, the existing payment systems of banks made it possible for business entities to make bank payments even in those regions where branches were physically closed. All this became possible thanks to the existence in Ukraine of a developed and extensive network of ATMs, self-service terminals, electronic banking and electronic commerce. Digitization of the financial system of Ukraine, which began in 2008 (about 5% of transactions using cards were electronic payments) and began its sustainable development starting in 2017 (entering the market of a completely virtual bank (neobank)).

Due to an increase in the level of financial inclusion and promotion of the development of digital financial services in recent years, as of the beginning of 2022, the majority of households and business entities in Ukraine could carry out official financial transactions remotely. It was this opportunity that made it possible to maintain the financial stability of economic entities and the population, as well as to transform instruments for ensuring economic security by state authorities.

In such conditions, there is a need to review approaches to assessing the country's economic security, taking into account the impact of financial digitalization, as well as assigning it a priority place in the system of relevant indicators for the general integrated indicator of economic security. It becomes important not only to develop an econometric approach to the comprehensive assessment of the state's economic security taking into account the level of digitalization, but also to determine the level of influence of each component in order to make the most effective management decisions in conditions of catastrophically limited financial resources of the state. It is under these conditions that state bodies of executive power will be able to maintain a sufficient level of economic security of the state and ensure a relative stability of the financial system.

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## 1. LITERATURE REVIEW

Given the existing scientific development in the field of economic security analysis, it should be noted that currently there is no established approach to its assessment. Thus, the study of Gryshova, Kyzym, Hubarieva et al. (2020) is focused on the use of international indices and ratings to assess the level of economic security. The authors used the standardization of thirteen international integral indicators (the Global Competitiveness Index, Index of Economic Freedom, the Global Enabling Trade Index, the Fragile States Index, KOF Index of Globalization, Human Development Index, World Happiness, Doing Business, the Worldwide Governance Indicators, the Democracy Index, Corruption Perceptions Index, the Legatum Prosperity Index, the Environmental Performance Index) that characterize economic, social, political, and ecological spheres of the state's development in order to form an integral indicator. The consolidated assessment is made based on the geometric mean both for each of the four spheres of the state's development and for the calculation of the integral indicator of economic security. In

parallel with this, researchers determine the relationship between the level of per capita GDP and individual indicators included in the integral indicator, which allows them to formulate proposals for the state policy of Ukraine, taking into account the practice of EU countries in ensuring economic security.

In the scientific literature, there are widespread studies devoted to assessing the influence of certain social processes or certain subjects of economic relations on economic security. Kośny and Piotrowska (2013) empirically try to determine the most relevant factors for ensuring the economic security of households in Poland. The scientists have established that the main factor ensuring this component of economic security is stable employment. In turn, it has been proven that the savings of Poles do not affect their economic security, that is, Polish households ensure it exclusively due to the availability of stable work.

As noted by Kolot et al. (2020), equally important for the economic security of the state is the development of the decent work institute in Ukraine,

which is based on the socio-labor model “Work 4.0” and is the result of large-scale and multi-vector technical and technological innovations, organizational and business changes that create new opportunities, risks and threats for economically active people in the digital ecosystem.

Ignatov (2019) places emphasis on the assessment of qualitative and quantitative indicators in the characteristics of EU member states, which makes it possible to determine the key triggers that cause violations of the country’s economic security. Based on the correlation analysis of economic security indicators and integrated international ratings, it was established that corruption, bureaucracy, low entrepreneurship culture, terrorism, organized crime, gaps in development between regions, and migration have a destructive effect on the economic security of EU countries.

The main drawbacks of the existing approaches to the building of integral indicators of economic security, the calculation of which are based on the existing international integral indicators, are the duplication of the selected ratings’ components. In addition, it is difficult to normalize these ratings according to a single methodology. All this can lead to distortions of the obtained results.

Yakymchuk et al. (2021) emphasize the need to take into account the impact of military operations on the territory of Ukraine in the process of economic security analysis. The study proved that the general indicator of economic security should take into account budgetary, monetary, currency, debt and banking security. It is proposed to evaluate the complex indicator of economic security using a taxonomic approach taking into account the specific weight of each relevant indicator that is included in one of the two groups of stimulators and destimulators. At the same time, having determined the further strategic priorities of the state policy on strengthening economic security based on the developed methodology, the sample of nine general indicators of the characteristics of various aspects of economic activity remains limited.

Zalizko et al. (2020) proposed a new system of weighting factors for such groups of indicators as demographic, energy, foreign economic, food,

ecological, epidemiological security. This allowed increasing the probability of forecasts of the country’s economic development in the conditions of epidemics and financial crises and, as a result, increasing the efficiency of state management of the economic security system. In addition, the non-alternative nature of the innovative concept implementation regarding the strengthening of Ukraine’s economic security based on digitalization of all branches of the national economy is substantiated.

Zachosova et al. (2018) studied banking security and financial market security as key components of economic security. The authors proposed three variants of the mechanism for ensuring economic security of financial institutions. The obtained results can be used by state regulators of the financial market in order to monitor the economic security of banks and non-bank financial institutions and further identify destructive mechanisms implemented by the heads of these institutions. Dubyna et al. (2021) also note the special role of digitalization in financial inclusion of the population, as well as the impact of these processes on the transformation of financial services. Kozmenko and Belova (2015) proved the importance of creating systemically important banks as a priority in the formation of stabilization measures for the country’s economy taking into account the fact that in Ukraine it is the banking sector that forms the biggest share of the financial market.

Kalinichenko and Lesyuk (2021) also focus on financial security as a key factor of economic security. The following main destabilizing factors were identified: imbalance of the state budget, high share of banks with foreign capital, deficit in the foreign trade balance, decrease in foreign exchange reserves, and devaluation. Koilo et al. (2020) defined government debt security based on the use of four indicators such as solvency, liquidity, internal and external debt of countries with emerging economies. Romenska et al. (2022) emphasize rather significant structural imbalances in the system of public finances of Ukraine, which negatively affect the stability of the entire financial system and, therefore, the financial security of the state. When studying the budget security of Ukraine at the level of territorial communities, Voznyak (2021) also substantiates the presence of

budget imbalances, which leads to imbalances in the financial system at the local level and forms budget risks and threats to the financial security of Ukraine with different time lags in the conditions of an unstable economy.

Haber et al. (2018) analyzed the financial component of economic security as the main element of ensuring sustainable financial development of a country. The authors examined the state of the country's financial security in terms of its key elements, which made it possible to identify the priority indicators and develop measures to prevent the existing threats to economic security. In addition, on the basis of regression analysis, scientists were able to predict the level of financial security of the country setting it at the level of 40.09%.

Bukhtiarova et al. (2020) determined the integral indicator of the level of effectiveness of the financial monitoring system in the Ukrainian banking system and substantiated the dependence of the country's level of financial security on measures aimed at countering the legalization of income obtained through criminal means.

Shkolnyk et al. (2020) made a comparative assessment of the level of financial security of Poland and Ukraine based on the use of Harrington's desirability function and identified the factors that determine it. For the financial security of Poland, the greatest factors were Freedom from corruption and Business freedom; for Ukraine – Business freedom and Trade freedom. Studies of possible ways of strengthening financial security are carried out in the work of Vyhovska et al. (2019).

However, the impact of digitalization on economic security receives insufficient attention in the scientific literature. The scientific work of Spivakovskyy et al. (2021) can be noted, which examines the advantages and disadvantages in the functioning of business entities in the digital economy, as well as the structural and sectoral transformations taking place because of this. The mechanism of smoothing the impact of digital transformation on the economic security of the state is determined. Having identified a tool for monitoring the development of a networked digital community – the Network Readiness Index, Spivakovskyy et al. (2021) propose a road map of reforms, the main essence of

which is to change the structure of management of economic systems at different levels. These changes mean the creation of network management structures with effective management of resources in real time and systematic coordination of participants. This work is aimed at a separate study of digitization and economic security, as well as determining the impact of the categories on each other. It should be noted that the goal of this study is the analysis of digitalization in the financial sector as an integral component of economic security and further analysis of its importance to ensure the goal of progressive development of the state.

Studying the digitalization in the financial sphere in order to take it into account in the process of researching economic security, Valverde and Fernández (2020) consider macroeconomic and microeconomic approaches to financial digitalization, as well as new approaches to determining the level of consumer acceptance of the digital financial system. The paper substantiates the lack of alternatives in the relationship between banks, FinTech and BigTech.

In turn, based on surveys of employees of 102 banks from Germany, Switzerland, and Liechtenstein, Niemand et al. (2021) concluded that the level of digitalization of a bank itself does not affect profitability. At the same time, banks should develop a clear vision of digitalization, which is characterized by innovation, readiness to be ahead of competitors and take risks. Similar conclusions were obtained by Zhou et al. (2021), who, after examining the listed banks in China during 2007–2019, concluded that digitalization does not directly improve the performance of existing companies, while banking and non-banking institutions benefit by reducing inertia.

Khamidov et al. (2021) built a hierarchical model of FinTech sectors in Ukraine based on indicators such as general indicators of online financial activity of the population, indicators of online and offline accumulation of funds, and indicators of credit activity. It is determined that the most promising areas of financial activity include payment instruments, analysis of financial assets, marketplaces, and neobanking. That is, the digitalization of banking products is the main vector of future innovative development in Ukraine.

Ha (2022) quantitatively measured the relationship between digital transformation and financial development. A positive impact of digitalization on the development of financial markets and institutions was determined based on the analysis of 27 European countries. Having calculated the short-term and long-term impact of digitalization, it was established that e-commerce and e-government have a long-term impact on financial markets and financial institutions.

Pakhnenko et al. (2021) investigated the level of digitalization of financial services in European countries and built an integral indicator of digitalization of financial services based on the Fishburn method and weighted sums, which includes three components such as digital inclusion, financial inclusion and digital financial services. The obtained results made it possible to divide European countries into four groups: with a high, medium, low and critically low level of digitalization of financial services. The first group included Denmark, the Netherlands, Great Britain, Finland, Sweden and Norway, i.e. countries with the highest standard of living and economic security in Europe. This confirms the hypothesis of a direct relationship between the level of digitization and economic security.

However, digitalization has also a negative impact on economic security – the challenges that appeared in the information sphere and the ways to overcome them are studied by Anderson et al. (2009). Therefore, digitization must be considered from both sides in order to ensure the state's economic security.

Having studied the existing work of scientists and analysts in ensuring and evaluating economic security, as well as the impact of digitalization on all processes of state development, it is possible to assert that there is no established approach to the identification of economic security and its components. Each country follows its own methods for assessing economic security based on the direct understanding of the specific category, as well as historical, financial, political and other national characteristics.

It should be noted that economic security in Ukraine is currently in a critical state, which is caused by Russia's military aggression. According

to the forecasts of the World Bank Group (2022), the fall in the GDP of Ukraine will be approximately 45%, and the growth of the economy will be very slow and may not start before the second half of 2023. The probability of such a forecast will depend primarily on the duration of hostilities on the territory of Ukraine. The Russian aggression in Ukraine significantly affected the global economic situation deepening the economic recession. Presenting IMF forecasts for 2022 and 2023, Nam (2022) notes that "The war in Ukraine slows the global recovery". The war unleashed by Russia in Ukraine caused a surge of scientific research on its impact not only on the state of the Ukrainian economy, but also on the world economy.

Anayi et al. (2022) note that the war in Ukraine is already affecting the world economy through indicators of economic uncertainty, which is due to a number of factors such as energy usage, import exposure, discretionary spending, and direct links of company directors to the conflict region. At the same time, the indicators of subjective uncertainty for Great Britain are much lower than during the Covid-19 pandemic. After investigating the impact of the Russia-Ukraine war on the constituent firms of the leading stock market indices of the G7 countries, Abbassi et al. (2022) point out that stock prices are fragile to geopolitical risks and trade dependence. At the same time, it was concluded that French and American companies do not feel the influence of the Russia-Ukraine war.

Wang et al. (2022), researching the transmission of returns and volatility in the universe of commodities around the war in Ukraine, note that the total volatility spillover increases from 35% to 85%, exceeding the level seen during the pandemic. Prohorovs (2022) notes that as a result of the war unleashed by Russia in Ukraine, a long-term, large-scale negative impact on most European companies and economies is formed, while the Russian war in Ukraine has become a powerful trigger, significantly increasing the level of inflation and exacerbating the existing issues of economies.

The group of experts from The Vienna Institute for International Economic Studies, Astrov et al. (2022), evaluating the economic effects of the Ukraine war for Ukraine and the rest of Europe,

note that Ukraine has lost its ability to sell more than half of its exports, primarily agricultural commodities and metals. Western financial support will become ever more important as the war continues. Four main areas of structural changes for the European Union have been identified: first, the EU will get more serious about defense. Second, the green transition will gather pace. Third, broader Eurasian economic integration will be unwound. And fourth, the EU accession prospects for countries in Southeast Europe could (and should) improve.

Sun and Zhang (2022) note that since the explosion of the Russia-Ukraine war, the global stock markets have experienced considerable oscillation. The study analyzed the stock markets of 86 countries and the influence of geopolitical, economic, institutional, humanitarian, industrial, and firm-related factors on them, as well as investigated the nature of heterogeneous abnormal returns for listed firms around the explosion of the war.

Mariotti (2022) argues that the Russian-Ukrainian war is a dramatic consequence of the growing imbalance and instability of the global economic and political order and empirically proves the slowdown of the world's economy in the long term, and the changing structure of global value chains.

Lim et al. (2022) describe the impact of war on business through the lens of the Ukrainian-Russian war, the consequences of which are the restriction of access to essential goods, an increase in the level of unemployment, a decrease in the purchasing power of the population, and inflation. A threat of cyberattacks and a threat to digital and sustainable growth are highlighted separately.

Based on the current economic state of Ukraine in the conditions of martial law, digitalization should be taken into account directly when forming an integral indicator of the state's economic security. At the same time, its main components should be the security of the financial sector, the stock market security, as well as debt and budget security. Digitalization affects economic security through the banking infrastructure, since digital innovations in the banking sphere make it possible for the population and

business entities to use banking services and products 24/7 in any part of Ukraine.

The use of integral indicators for the purpose of researching complex phenomena with prior normalization of input indicators is comprehensively used by scientists to study various spheres of social (Yegorshin et al., 2021), economic (Baida et al., 2020) and environmental (Strijov et al., 2011) life of the population. El Gibari et al. (2019) prove the widespread use of multi-criteria decision-making methods in the economic literature to build composite indicators. Gan et al. (2017) suggest using a process-oriented approach for the correct choice of weighting and aggregation methods. In turn, Matteo Mazziotta et al. (2016) emphasize that to obtain adequate results of economic research, special attention must be paid to selecting relevant factors when forming an integral indicator. The entropy method was used to calculate the general indicator of the standard of living in the regions of Ukraine (Haustova & Omelchenko, 2011). The approach offered by Zhou et al. (2010) to determine the specific weight of the components of the UN Human Development Index in 27 countries based on the multiplicative model is interesting. This makes it possible to avoid subjectivism when determining weighting factors for sub-indicators.

## 2. METHODOLOGY

The period 2015–2021 was chosen for this study based on the following positions: firstly, starting from 2015 statistical information does not reflect data from territories not under Ukraine's control, and secondly, starting from 2015, financial regulators of Ukraine have taken reform steps on the financial market. This led to the transition of statistical indicators to a new relevant range, within which The research tested the hypothesis that the processes of digitization, that took place in the financial sector in recent years allowed to maintain the financial architecture of Ukraine in the first weeks of active military operations and maintain a high level of payment capabilities. The study was conducted in several stages.

Stage 1. Formation of an input array of data for characteristics of financial sector security, stock

market security, debt and budget security, as well as digitalization.

Stage 2. Normalization of relevant indicators of all components of economic security and digitalization, taking into account their peculiarities.

Stage 3. Determination of integral indicators for evaluating specified components of economic security based on Harrington's approach.

Stage 4. Determination of specific weight for the influence of each component of economic security with the help of factor analysis.

Stage 5. Formation of an integral indicator of the country's economic security is calculated based on the use of the multiplicative Kinney convolution.

The financial sector's security is considered as the stability of banks and other financial corporations. Therefore, it is proposed to include seventeen indicators with characteristics of banking activity and two indicators with characteristics of other financial corporations into the complex indicator of the financial sector's characteristics: the ratio of regulatory capital to risk-weighted assets, the ratio of non-performing loans to total gross loans, the share of total gross loans: residents, the share in total gross loans: non-financial corporations, the share in total gross loans: non-residents, rate of return on assets, rate of return on capital, ratio of interest margin to gross income, the ratio of liquid assets to total assets, ratio of liquid assets to short-term liabilities, ratio of net open position in foreign currency to capital, the ratio of gross position of derivative financial instruments in assets to capital, the ratio of capital to assets, the spread between loan and deposit rates (basic points), the ratio of customer deposits to total gross loans (except interbank loans), the ratio of loans in foreign currency to total gross loans, the ratio of liabilities in foreign currency to total liabilities, the ratio of financial assets of other financial corporations to total financial assets, the ratio of financial assets of other financial corporations to gross domestic product.

In turn, the input array of data for evaluating other components of economic security will be much smaller, which is caused by the bank-centric model of the Ukrainian financial system and,

accordingly, the predominant role of banks in ensuring the effective activity of economic agents. Therefore, the safety of the stock market consists of indicators such as the ratio of private debt securities to GDP, the ratio of state debt securities to GDP, PFTS Index.

Debt security includes the ratio of state and guaranteed state debt to GDP, the ratio of gross external debt to GDP, the weighted average yield of government bonds on the primary market, the ratio of international reserves to gross external debt, and the ratio of international reserves to expenditures on debt servicing and repayment.

Budgetary security consists of the following indicators: the deficit/surplus of public debt to GDP, the level of redistribution of GDP through the consolidated budget, the share of debt servicing expenses in the state budget revenues.

Turning to the characteristics of digitalization, it should be noted that it is proposed to be described by two groups of indicators, namely general and specific. The general indicators should include: fixed broadband subscriptions (per 100 people), secure internet servers (per 1 million people), mobile cellular subscriptions (per 100 people), individuals using the internet (% of population). These are the indicators that characterize the general development of digitization in the country. The group of specific indicators includes: the number of electronic payment mediums, the validity period of which has not expired, the number of electronic payment mediums for which at least one spending transaction was carried out during the reporting period, the number of ATMs, the number of deposit ATMs, the number of self-service software and technical complexes, commercial payment terminals, bank payment terminals, the number of business entities that accept electronic payment mediums. The second group of digitalization indicators characterizes the level of informatization of the banking sector, which had a major impact on the effectiveness of the banking system during the period of active military operations on the territory of Ukraine.

At the second stage of the researched methodology, in order to normalize relevant indicators for the characteristics of the economic security compo-



nents, it is proposed to use the geometric mean for the security of the financial sector, the security of the stock market, debt and budget security, and exponential mean for digitalization.

To normalize indicators for simulators of financial sector security, stock market security, debt and budget security on the basis of a linear approach, it is necessary to solve the following equations:

$$\begin{cases} b_0 + b_1 \cdot \min_i b_i = -\ln(-\ln(\min^*)) \\ b_0 + b_1 \cdot \max_i b_i = -\ln(-\ln(\max^*)) \end{cases} \quad (1)$$

where  $b_0$  – free coefficient of linear dependence of the normalized and non-normalized indicator of financial sector security, stock market security, debt and budget security, respectively;  $b_1$  – the coefficient of influence of the values of non-normalized indicator of financial sector security, stock market security, debt and budget security on its comparable level;  $\min_i b_i$  – minimum value of the  $i$ -th indicator;  $\max_i b_i$  – maximum value of the  $i$ -th indicator;  $\min^*$  – minimum value of the Harrington function for the worst value of desirability function; let's assume it is equal to 0.37, as a consequence,  $-\ln(-\ln(\min^*)) = -\ln(-\ln(0.37)) = 0.0005764$ ;  $\max^*$  – maximum value of the Harrington function for the best value of the desirability function; let's assume it is equal to 0.99, as a consequence,  $-\ln(-\ln(\max^*)) = -\ln(-\ln(0.99)) = 4.600149$ .

To normalize the indicators of disincentives for financial sector security, stock market security, debt and budget security on the basis of a linear approach, it is necessary to solve a system of equations:

$$\begin{cases} b_0 + b_1 \cdot \max_i b_i = -\ln(-\ln(\min^*)) \\ b_0 + b_1 \cdot \min_i b_i = -\ln(-\ln(\max^*)) \end{cases} \quad (2)$$

The solving of system (1) makes it possible to obtain the following ratio:

$$\begin{cases} b_1 = \frac{\ln(-\ln(\min^*)) - \ln(-\ln(\max^*))}{\max_i b_i - \min_i b_i} \\ b_0 = \frac{\min_i b_i \cdot \ln(-\ln(\max^*)) - \max_i b_i \cdot \ln(-\ln(\min^*))}{\max_i b_i - \min_i b_i} \end{cases} \quad (3)$$

The solving of system (2) makes it possible to obtain the following ratio:

$$\begin{cases} b_1 = \frac{\ln(-\ln(\min^*)) - \ln(-\ln(\max^*))}{-\max_i b_i + \min_i b_i} \\ b_0 = \frac{\max_i b_i \cdot \ln(-\ln(\max^*)) - \min_i b_i \cdot \ln(-\ln(\min^*))}{-\max_i b_i + \min_i b_i} \end{cases} \quad (4)$$

Taking into account formulas (3) and (4), it can be written:

$$b_i' = b_0 + b_1 \cdot b_i, \quad (5)$$

where  $b_i'$  – normalized value of the  $i$ -th indicator of financial sector security, stock market security, debt and budget security;  $b_i$  – the actual value of the  $i$ -th input indicator.

In turn, the normalization of digitalization assessment indicators is carried out by using the Harrington approach:

$$d_i' = \frac{2 \cdot d - (\max_i d_i + \min_i d_i)}{\max_i d_i - \min_i d_i}, \quad (6)$$

where  $d_i'$  – normalized value of the  $i$ -th digitization indicator;  $d$  – the actual value of the  $i$ -th digitization indicator.

Given the specifics of the implementation of the *third stage* of the methodological approach to assessing economic security, it should be noted that the determination of Harrington's desirability function and the calculation of the integral indicator of financial sector security, stock market security, debt and budget security are carried out on the basis of the geometric mean:

$$p_i = \exp(-\exp(-b_i')), \quad (7)$$

where  $p_i$  – desirability function for the  $i$ -th indicator of financial sector security, stock market security, debt and budget security.

$$IP_j = \sqrt[m]{\prod_{i=1}^m p_{ji}}, \quad (8)$$

where  $IP_j$  – integral indicator of the  $j$ -th component of the country's economic security.

The integral digitization indicator is determined using the Harrington method based on the mean exponential as a sum of the basic digitization component and the total digitization component, which are calculated according to the formula:

$$\begin{aligned} IP_j &= \exp\left(-\prod_{i=1}^q \left(-\ln d_{ij}'\right)^{w_i}\right) = \\ &= \exp\left(-\exp\left(-\sum_{i=1}^q w_i \cdot d_{ij}'\right)\right), \end{aligned} \quad (9)$$

where  $IP_j$  – an integral indicator of the  $j$ -th component of the country's economic security, in this case, digitalization.

The importance of considering the financial digitalization indicator became obvious in the first month of the war with Russia, since it was a stable and uninterrupted operation of payment systems, the ability for people to pay when making purchases by using payment cards and POS terminals that ensured the prevention of panic among the population. In addition, a very important role was played by a number of technological solutions offered by banks, which made it possible to accept non-cash payments using payment cards even without using physical POS terminals. The most popular services were: POS PHONE - from Visa, "QR-code", "NFC-tag", "Terminal" – from JSC CB PRIVATBANK; RaiPos – from JSC Raiffeisen Bank; FROG – from Mastercard; OshchadPAY – from JSC Oshchadbank.

At the fourth stage, the specific weight of the influence of all components of economic security on the integral indicator is determined using factor analysis implemented by the method of principal components.

The fifth stage of the studied methodology consists in the development of an integral indicator of the country's economic security. It is implemented using the multiplicative convolution of Keene integral indicators of financial sector security, stock market security, debt and budget security and digitalization weighted by factors calculated in accordance with the method of principal components:

$$IEB_t = \frac{1}{k} \left\{ \prod_{i=1}^k (1 + k \cdot w_j \cdot IP_{ij}) - 1 \right\}, \quad (10)$$

where  $IEB_t$  – integral indicator of the country's economic security for the  $t$ -th year;  $k$  – the total number of components of the country's economic security;  $w_j$  – specific weight of the  $j$ -th component of the country's economic security determined by the method of principal components;  $IP_{ij}$  – integral indicator of the  $j$ -th component of the country's economic security for the  $t$ -th year.

To move from the absolute integral indicator of the country's economic security for the  $t$ -th year ( $IEB_t$ ) to the relative indicator, the following ratio is used:

$$VIEB_t = \frac{IEB_t}{\max_i IEB_i + 3 \cdot \sigma}, \quad (11)$$

where  $\sigma$  – mean squared deviation of the absolute integral indicator of the country's economic security.

### 3. RESULTS AND DISCUSSION

The practical results of the implementation of the first two stages to assessing Ukraine's economic security taking into account digitalization are presented in Tables A1, A3, A5, A7, A9, A11 (input array of data) and A2, A4, A6, A8, A10, A12 (normalized values of the relevant indicators).

Examining the results of the determination of integral indicators for financial sector security, stock market security, debt and budget security, as well as digitalization (Table 1), it should be noted that their absolute values give an opportunity to identify only the direction and volatility of one or another aspect of economic security, since the main goal of the methodology is to determine the specific weight of the influence of each of them and further identify the integral indicator.

It can be noted that the financial sector security increased in 2015. In the following period it had a steady tendency towards stability of eigenvalues. This fully corresponds to the real situation in the domestic banking sector, which passed this period without upheavals, while the central bank raised the standards for capital adequacy clearing the market from captive and inefficient banks.

**Table 1.** Integral indicators for assessing financial sector security, stock market security, debt and budget security, as well as digitalization

Year/ quarter	Integral indicators of evaluation				
	Financial sector security	Budget security	Debt security	Stock market security	Digitization
2015Q1	0.578	0.962	0.548	0.656	0.423
2015Q2	0.721	0.943	0.749	0.880	0.395
2015Q3	0.793	0.980	0.854	0.840	0.357
2015Q4	0.832	0.728	0.882	0.747	0.351
2016Q1	0.830	0.944	0.564	0.677	0.300
2016Q2	0.788	0.914	0.776	0.659	0.303
2016Q3	0.834	0.915	0.906	0.742	0.292
2016Q4	0.831	0.818	0.872	0.757	0.297
2017Q1	0.861	0.929	0.849	0.624	0.344
2017Q2	0.860	0.956	0.844	0.799	0.354
2017Q3	0.867	0.971	0.919	0.767	0.404
2017Q4	0.859	0.814	0.879	0.842	0.432
2018Q1	0.828	0.937	0.845	0.843	0.447
2018Q2	0.801	0.903	0.850	0.900	0.445
2018Q3	0.812	0.968	0.832	0.843	0.457
2018Q4	0.795	0.821	0.757	0.948	0.474
2019Q1	0.806	0.943	0.812	0.924	0.641
2019Q2	0.794	0.924	0.865	0.869	0.643
2019Q3	0.806	0.959	0.922	0.819	0.667
2019Q4	0.820	0.825	0.916	0.772	0.689
2020Q1	0.821	0.940	0.905	0.756	0.795
2020Q2	0.811	0.790	0.873	0.710	0.743
2020Q3	0.823	0.841	0.929	0.708	0.762
2020Q4	0.834	0.370	0.805	0.721	0.806
2021Q1	0.825	0.926	0.917	0.746	0.997
2021Q2	0.812	0.811	0.917	0.750	1.000
2021Q3	0.811	0.876	0.922	0.754	1.000
2021Q4	0.821	0.636	0.927	0.765	1,000

The budget security indicator is the most cyclical one, which is explained by the specifics of the budget process in the state, when at the end of the year there are not enough financial resources to cover current expenditures. The most critical situation in terms of budget security is observed in the fourth quarter of 2020, when the public debt deficit was almost 17% of GDP.

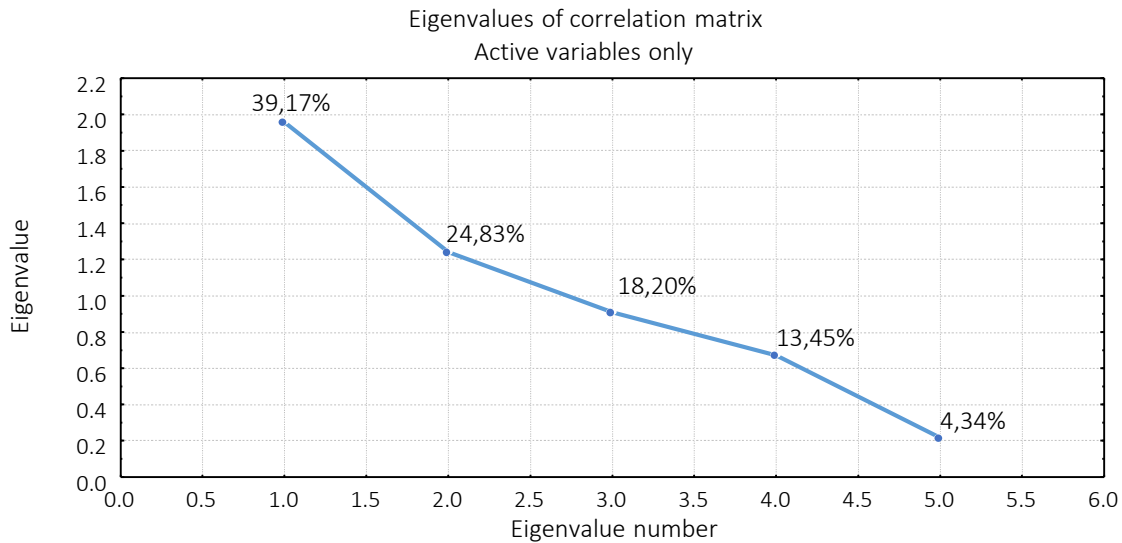
Debt security in Ukraine has cyclical dynamics fully correlated with the volume of state and external debt. The most critical periods for debt security were the first quarter of 2015 and 2016, as well as the fourth quarter of 2018 and 2020, when the state actively attracted resources on the domestic and foreign markets

The integral indicator of the stock market security also developed unevenly. The cyclicity of its

dynamics in 2015–2018 changed to a downward trend for the next three years.

Only the integral level of digitalization is characterized by the growing trend. Since 2017, this indicator has grown by 3.7 times. This fully corresponds to the pace of digitalization of Ukrainian society and active investments of financial institutions in the field of electronic commerce.

Moving on to the practical implementation of the stage of determining the impact of the financial sector security, the stock market security, debt and budget security, as well as digitization on the economic security of the country, it should be noted that it is proposed to be carried out with the help of factor analysis by using the of the Statistics 11 software complex. So, at the first step, a scree plot (Figure 1) of the eigenvalues of the correlation



**Figure 1.** Determining the contribution of each of five components of economic security using the scree plot method

matrix is built, which allows determining the variation of each of the five studied factors. Depending on which factor will provide the greatest variation, the following calculations will be carried out. Thus, the calculation results indicate the need to consider the first factor, since it provides the largest share of variation at the level of 39.17%.

At the second step, in the context of the first factor chosen at the previous step as the basic one, this study will determine the share of integral indicators for assessing the security of the financial sector, security of the stock market, debt and budgetary security, and digitalization. This step is implemented as follows: Statistics/Multivariate Exploratory Techniques/Principal Component and Classification Analysis. The results obtained are grouped in Table 2.

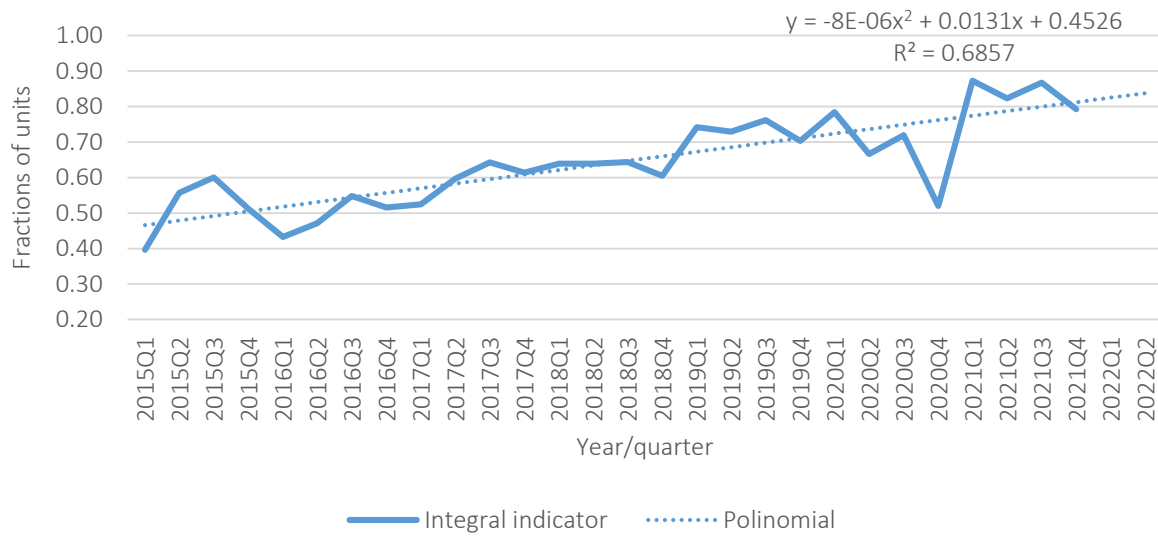
**Table 2.** Specific weight of integral indicators for evaluating financial sector security, stock market security, debt and budget security, and digitalization

Integral indicators of evaluation	Specific weight
Financial sector security	0.25
Budget security	0.18
Debt security	0.39
Stock market security	0.0007
Digitalization	0.22

Table 2 shows that debt security in the amount of 37% has the greatest influence on the integral indicator of economic security, which, given the con-

stant budget deficit and correspondingly high dependence on external and internal borrowing, is quite logical. In recent years, Ukraine has been an active player on the domestic and foreign capital markets. This type of security requires special attention, given that earned money is only sufficient to pay off interest on loans.

In recent years, Ukraine has demonstrated clear compliance with payment discipline regarding the fulfillment of its obligations both in terms of domestic and especially foreign debt, which was confirmed by the improvement of credit ratings in recent years. The situation in 2022 has changed radically and, given the significant reduction of the country's GDP as a result of hostilities, significant problems in filling the revenue part of budgets at all levels, as well as significant costs for ensuring defense capability, Ukraine is currently unable to fulfill its obligations in a full and timely manner its debt service obligations. In this regard, negotiations are underway with the International Monetary Fund regarding the revision of the payment schedule for the external state debt. In addition, on July 20, 2022, a group of creditors of Ukraine consisting of Canada, France, Germany, Japan, the United Kingdom and the United States published a statement regarding their agreement to postpone debt service payments from August 1, 2022 until the end of 2023, with the further possibility of extending it for a year. Such a situation will make it possible for Ukraine to reduce the burden on the state budget



**Figure 2.** Dynamics of the integral indicator of Ukraine's economic security during 2015–2022

and reduce the formation of new state debt, which increases under martial law. Such a step on the part of the G7 countries is a powerful signal, including for the International Monetary Fund and other creditors, regarding financial support for Ukraine.

The security of the financial sector with a specific weight of influence at the level of 25% is in the second place. This is an adequate result, given the significant influence of the banking sector on the entire financial life of Ukraine.

Digitalization occupies the third position and affects the state's economic security at the level of 22%. The obtained results confirm the hypothesis put forward at the beginning of the study about the significant impact of digitalization on the country's economic security.

The impact of budgetary security on the state's economic security is also significant at the level of 15%. Budgetary discipline and balanced spending of available resources definitely affects the economic stability of the state.

The stock market security has almost no influence, which is quite logical based on the low level of development of this market in Ukraine and the bank-centric model of development of the country's financial system.

Evaluating the dynamics of the obtained integral indicator of economic security for seven years, it can be

seen that on average its value increased from the level of 0.32 units in 2015 to the level of 0.63 units in 2021, i.e. a two-fold increase (Figure 2). For the most part, this happened due to the positive impact of digitalization, as all other components of economic security either slowly decreased or had a stable character.

It can be stated that the margin of economic safety accumulated over seven and a half years, due to the intensive digitization of the financial sector, allowed Ukraine to withstand the first weeks of the war and not lose state control over the financial system while ensuring a sufficient level of functioning payment system in the country.

The results obtained partially coincide with the results obtained by Haber et al. (2018) regarding the weight of the influence of various components of financial security on the state of economic security, but this study did not take into account the role of financial digitalization processes. In addition, the results of the study are partly consistent with the findings of Kalinichenko and Lesyuk (2021) regarding the essential importance of fiscal security. Thus, the approaches proposed in the study can be used in the future, but taking into account the fact that they should be based on a new relevant range, the beginning of which will be in March 2022, after the start of the war.

The results obtained can be used to compare the state of economic security and determine the impact of the war on its main elements.

## CONCLUSION

The paper proposes to consider economic security as part of five components: financial sector security, stock market security, debt and budget security, and digitalization. The greatest attention is paid to the financial sector security based on the bank-centric model of the financial system in Ukraine. It was determined that the greatest impact on the integral indicator of economic security is made by debt security at the level of 37%. The financial sector security at the level of 25% is in the second place. Digitalization occupies the third position with an impact at the level of 22%, followed by budget security, which affects the economic security at the level of 15%. The stock market security, the influence of which is not even 1%, is in the last place. The results of calculations confirmed the proposed hypothesis that it was digitalization that made it possible to preserve reliable functioning of the banking system in the conditions of active hostilities on the territory of Ukraine and to maintain the minimum living standards for the population.

The proposed scientific and methodological approach to assessing the state's economic security, taking into account the level of digitalization, is definitely not without its drawbacks. For example, it does not allow obtaining an objective, quantitative assessment of each component: financial sector security, stock market security, debt and budget security, as well as digitalization. In addition, the qualitative interpretation of the obtained quantitative values of the integral indicator for economic security remains insufficiently substantiated. All this will be researched in the future.

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## APENDIX A

**Table A1.** Information base for the study of the financial sector security in Ukraine

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
The ratio of regulatory capital to risk-weighted assets	8,35	9,03	7,09	12,31	12,03	13,03	14,22	12,69	...	22,59	21,65	21,59	18,01
The ratio of non-performing loans to total gross loans	24,70	24,27	25,58	28,03	29,69	30,37	31,01	30,47	...	39,93	37,18	33,26	30,02
Share in total gross loans: Residents	95,43	95,06	94,90	94,54	95,00	96,33	95,84	95,92	...	95,90	95,93	96,13	96,20
Share in total gross loans: Non-financial corporations	71,89	73,66	75,54	75,29	76,32	77,45	78,05	78,55	...	72,08	71,35	70,33	69,14
Share in total gross loans: Non-residents	4,57	4,94	5,10	5,46	5,00	3,67	4,16	4,08	...	4,10	4,07	3,87	3,80
Rate of return on assets	-23,53	-12,10	-6,88	-5,54	-2,39	-1,96	-1,11	-12,47	...	2,65	3,56	4,01	4,46
Rate of return on capital	-277,3	-147,2	-80,26	-65,51	-25,93	-19,96	-10,76	-122,1	...	22,48	30,99	34,69	37,86
The ratio of interest margin to gross income	14,20	42,93	47,99	39,00	59,38	55,94	48,17	45,94	...	59,95	54,39	53,80	53,11
The ratio of liquid assets to total assets	26,75	27,87	29,92	33,00	35,56	38,41	39,36	48,53	...	70,53	70,87	69,35	69,24
The ratio of liquid assets to short-term liabilities	78,76	79,60	83,80	92,87	89,54	88,69	88,41	92,09	...	88,91	89,72	89,21	89,13
The ratio of net open position in foreign currency to capital	86,15	76,37	97,29	36,15	39,84	40,35	44,08	57,07	...	32,37	32,69	31,54	30,67
The ratio of gross position of derivative financial instruments in assets to capital	13,15	8,33	6,40	12,55	11,61	9,42	11,08	36,81	...	0,84	1,13	0,94	0,62
The ratio of capital to assets	5,98	7,64	9,70	8,02	10,35	11,05	11,78	9,78	...	11,91	11,14	12,02	12,49
Spread between loan and deposit rates (basis points)	536	460	633	772	554	542	569	600	...	785	863	740	786
The ratio of customer deposits to total gross loans (except interbank loans)	62,60	65,32	66,93	71,22	72,95	79,36	78,90	80,51	...	140,06	140,19	135,93	140,34
The ratio of loans in foreign currency to total gross loans	57,37	54,44	54,85	57,90	59,29	56,89	55,41	51,35	...	37,64	34,37	32,00	31,55
The ratio of liabilities in foreign currency to total liabilities	56,11	52,75	52,55	52,82	55,14	52,87	54,46	55,92	...	38,96	37,29	36,01	33,65
The ratio of financial assets of other financial corporations to total financial assets	25,02	27,18	27,92	26,97	26,35	27,90	27,97	26,45	...	28,25	28,50	29,28	28,53
The ratio of financial assets of other financial corporations to gross domestic product	27,86	26,84	25,10	22,35	21,65	21,49	20,88	17,91	...	15,85	16,09	17,73	14,50

**Table A2.** Normalized values of indicators for characteristics of the financial sector security in Ukraine

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
The ratio of regulatory capital to risk-weighted assets	0,37	0,57	0,01	1,51	1,43	1,72	2,06	1,62	...	4,48	4,21	4,19	3,16
The ratio of non-performing loans to total gross loans	4,54	4,60	4,42	4,08	3,86	3,76	3,67	3,75	...	2,45	2,83	3,37	3,81
Share in total gross loans: Residents	0,89	1,25	1,41	1,76	1,31	0,01	0,49	0,41	...	0,43	0,40	0,20	0,13
Share in total gross loans: Non-financial corporations	1,35	2,21	3,13	3,01	3,51	4,06	4,36	4,60	...	1,44	1,08	0,59	0,01
Share in total gross loans: Non-residents	0,89	1,25	1,41	1,76	1,31	0,01	0,49	0,41	...	0,43	0,40	0,20	0,13
Rate of return on assets	0,01	1,75	2,55	2,75	3,23	3,30	3,43	1,69	...	4,00	4,14	4,21	4,28

**Table A2 (cont.).** Normalized values of indicators for characteristics of the financial sector security in Ukraine

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
Rate of return on capital	0,01	1,85	2,79	3,00	3,56	3,65	3,78	2,20	...	4,25	4,37	4,42	4,46
The ratio of interest margin to gross income	0,01	2,76	3,25	2,39	4,34	4,01	3,27	3,05	...	4,40	3,86	3,81	3,74
The ratio of liquid assets to total assets	0,01	0,11	0,31	0,61	0,86	1,13	1,22	2,11	...	4,23	4,26	4,11	4,10
The ratio of liquid assets to short-term liabilities	0,01	0,20	1,19	3,31	2,53	2,33	2,27	3,13	...	2,38	2,57	2,45	2,44
The ratio of net open position in foreign currency to capital	3,85	3,18	4,60	0,46	0,71	0,74	0,99	1,87	...	0,20	0,22	0,14	0,08
The ratio of gross position of derivative financial instruments in assets to capital	1,64	1,04	0,80	1,57	1,45	1,17	1,38	4,60	...	0,10	0,14	0,11	0,07
The ratio of capital to assets	0,01	0,93	2,08	1,14	2,45	2,84	3,24	2,13	...	3,32	2,89	3,38	3,64
Spread between loan and deposit rates (basis points)	0,86	0,01	1,95	3,52	1,06	0,93	1,23	1,58	...	3,67	4,54	3,16	3,68
The ratio of customer deposits to total gross loans (except interbank loans)	0,01	0,17	0,26	0,51	0,62	1,00	0,97	1,06	...	4,58	4,59	4,34	4,60
The ratio of loans in foreign currency to total gross loans	4,28	3,80	3,86	4,37	4,60	4,20	3,96	3,29	...	1,01	0,47	0,08	0,01
The ratio of liabilities in foreign currency to total liabilities	4,60	3,91	3,87	3,93	4,40	3,94	4,26	4,56	...	1,09	0,75	0,49	0,01
The ratio of financial assets of other financial corporations to total financial assets	0,01	1,81	2,43	1,63	1,12	2,41	2,47	1,20	...	2,70	2,91	3,56	2,94
The ratio of financial assets of other financial corporations to gross domestic product	4,60	4,26	3,68	2,76	2,53	2,48	2,27	1,29	...	0,60	0,68	1,23	0,15

**Table A3.** Information base for the study of budgetary security in Ukraine

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
Deficit/surplus of public debt to GDP, %	1,11	-0,46	1,55	-7,67	-2,32	-6,55	-9,44	-9,70	...	-2,49	-3,64	-2,62	-11,44
The level of redistribution of GDP through the combined budget, %	0,34	0,35	0,26	0,42	0,35	0,36	0,31	0,39	...	0,33	0,37	0,27	0,39
Specific weight of debt servicing expenses in state budget revenues, %	0,12	0,15	0,14	0,18	0,10	0,13	0,13	0,18	...	0,20	0,26	0,25	0,29

**Table A4.** Normalized values of indicators for the budgetary security of Ukraine

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
Deficit/surplus of public debt to GDP, %	3,89	3,54	3,98	1,96	3,13	2,20	1,57	1,51	...	-2,49	-3,64	-2,62	-11,44
The level of redistribution of GDP through the combined budget, %	2,58	2,21	4,60	0,30	2,14	2,03	3,34	1,19	...	0,33	0,37	0,27	0,39
Specific weight of debt servicing expenses in state budget revenues, %	3,93	3,28	3,46	2,67	4,41	3,65	3,71	2,54	...	0,20	0,26	0,25	0,29

**Table A5.** Information base for the study of debt security in Ukraine

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
The ratio of state and guaranteed state debt to GDP	405,4	314,9	268,3	266,9	375,7	311,4	264,8	266,9	...	246,1	211,7	160,9	154,4
The ratio of gross external debt to GDP	204,4	157,0	134,8	140,3	203,2	165,4	141,3	135,6	...	118,6	103,0	77,7	75,1
The weighted average yield of Domestic Government Loan Bonds on the primary market		12,7	11,6	10,8	19,4	16,9	7,9	7,7	...	10,9	11,6	12,0	11,3
The ratio of international reserves to gross external debt, %	30,4	30,1	36,0	38,6	36,1	39,2	42,6	43,1		62,3	63,0	64,5	64,9
The ratio of international reserves to debt servicing and repayment costs, %	405,4	314,9	268,3	266,9	375,7	311,4	264,8	266,9	...	246,1	211,7	160,9	154,4

**Table A6.** Normalized values for indicators of Ukraine's debt security characteristics

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
The ratio of state and guaranteed state debt to GDP	0,01	1,66	2,52	2,54	0,55	1,73	2,58	2,54	...	2,92	3,55	4,48	4,60
The ratio of gross external debt to GDP	0,01	1,69	2,48	2,29	0,05	1,39	2,25	2,45	...	3,06	3,61	4,51	4,60
The weighted average yield of Domestic Government Loan Bonds on the primary market	7,50	2,76	3,16	3,46	0,22	1,18	4,54	4,60	...	3,42	3,17	3,00	3,25
The ratio of international reserves to gross external debt, %	0,05	0,01	0,72	1,04	0,73	1,11	1,52	1,59		3,91	4,00	4,19	4,23
The ratio of international reserves to debt servicing and repayment costs, %	2,69	4,60	2,35	2,78	3,03	1,56	2,47	1,18		1,28	1,16	1,14	1,18

**Table A7.** Information base for the study of the stock market security in Ukraine

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
The ratio of private debt securities to GDP,	0,1	0,2	0,2	0,4	0,1	0,1	0,2	0,1	...	0,02	0,02	0,02	0,02
The ratio of government debt securities to GDP, %	8,7	4,5	1,8	4,7	3,3	4,3	2,7	3,0	...	4,2	3,1	2,7	2,1
PFTS index	413,8	350,8	301,1	240,7	225,7	223,0	239,9	265,2	...	517,2	531,2	526,3	522,8

**Table A8.** Normalized values for indicators of Ukraine's stock market security characteristics

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
The ratio of private debt securities to GDP,	1,68	2,04	1,87	4,60	1,72	1,63	2,58	1,44	...	0,22	0,20	0,21	0,26
The ratio of government debt securities to GDP, %	0,01	2,71	4,42	2,56	3,48	2,82	3,86	3,65	...	2,93	3,65	3,88	4,23
PFTS index	2,51	1,68	1,03	0,24	0,04	0,01	0,23	0,56	...	3,86	4,04	3,98	3,93

**Table A9.** Information base for the study of digitization's general indicators

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
Fixed broadband subscriptions (per 100 people)	11,6	11,6	11,6	11,6	12,0	12,0	12,0	12,0	...	18,6	18,6	18,6	18,6
Secure Internet servers (per 1 million people)	141,8	141,8	141,8	141,8	1905,5	1905,5	1905,5	1905,5	...	8952,5	8952,5	8952,5	8952,5
Mobile cellular subscriptions (per 100 people)	142,0	142,0	142,0	142,0	133,2	133,2	133,2	133,2	...	129,3	129,3	129,3	129,3
People who use the Internet (% of the population)	48,9	48,9	48,9	48,9	53,0	53,0	53,0	53,0	...	75,0	75,0	75,0	75,0

**Table A10.** Normalized values of general digitization indicators

Indicator	Year/quarter												
	2015 Q1	2015 Q2	2015 Q3	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	...	2021 Q1	2021 Q2	2021 Q3	2021 Q4
Fixed broadband subscriptions (per 100 people)	-1,00	-1,00	-1,00	-1,00	-0,91	-0,91	-0,91	-0,91	...	0,54	0,54	0,54	0,54
Secure Internet servers (per 1 million people)	-1,00	-1,00	-1,00	-1,00	-0,81	-0,81	-0,81	-0,81	...	-0,04	-0,04	-0,04	-0,04
Mobile cellular subscriptions (per 100 people)	1,00	1,00	1,00	1,00	-0,24	-0,24	-0,24	-0,24	...	-0,78	-0,78	-0,78	-0,78
People who use the Internet (% of the population)	-1,00	-1,00	-1,00	-1,00	-0,75	-0,75	-0,75	-0,75	...	0,59	0,59	0,59	0,59

**Table A11.** Information base for the study of digitization's specific indicators

Year/quarter	Quantity (pieces, units)							
	Electronic means of payment that have not expired (in circulation)	Electronic means of payment, with which at least one debit transaction was carried out during the reporting period	Self-service banking devices			Payment terminals		business entities that accept electronic means of payment
			ATMs	Deposit ATMs	Self-service software and technical complexes	Commercial	Banking	
2015Q1	70 550 630	33 042 496	36 596	0	0	178 875	24 935	123 505
2015Q2	70 298 465	32 618 546	36 060	0	0	165 091	22 589	116 536
2015Q3	65 387 918	30 096 387	34 325	0	0	162 740	21 160	114 809
2015Q4	61 813 024	30 197 919	33 424	0	0	168 720	20 717	121 741
2016Q1	59 306 608	30 837 750	33 334	0	0	174 293	20 185	131 264
2016Q2	58 210 741	30 710 152	33 552	0	0	181 638	20 914	124 822
2016Q3	57 493 269	30 875 896	33 628	0	0	179 504	18 877	128 062
2016Q4	56 454 426	31 141 161	33 467	0	0	188 435	18 844	139 067
...	...	...	...	...	...	...	...	...
2021Q1	73 430 290	40 449 737	18 789	2 425	15 967	374 995	13 963	326 941
2021Q2	75 301 369	40 791 742	18 784	2 582	15 905	381 997	13 889	333 504
2021Q3	76 027 831	41 272 800	18 748	2 616	15 743	406 360	13 931	356 043
2021Q4	89 105 041	46 288 895	18 459	2 914	15 159	426 537	12 623	371 578

**Table A12.** Normalization of the values of digitalization specific indicators

Year/quarter	Electronic means of payment that have not expired (in circulation)	Electronic means of payment, with which at least one debit transaction was carried out during the reporting period	Quantity (pieces, units)					Business entities that accept electronic means of payment
			Self-service banking devices			Payment terminals		
			ATMs	Deposit ATMs	Self-service software and technical complexes	Commercial	Banking	
2015Q1	-0,14	-0,64	1,00	-1,00	-1,00	-0,88	1,00	-0,93
2015Q2	-0,15	-0,69	0,94	-1,00	-1,00	-0,98	0,62	-0,99
2015Q3	-0,45	-1,00	0,76	-1,00	-1,00	-1,00	0,39	-1,00
2015Q4	-0,67	-0,99	0,66	-1,00	-1,00	-0,95	0,31	-0,95
2016Q1	-0,83	-0,91	0,65	-1,00	-1,00	-0,91	0,23	-0,87
2016Q2	-0,89	-0,92	0,67	-1,00	-1,00	-0,86	0,35	-0,92
2016Q3	-0,94	-0,90	0,68	-1,00	-1,00	-0,87	0,02	-0,90
2016Q4	-1,00	-0,87	0,66	-1,00	-1,00	-0,81	0,01	-0,81
...	...	...	...	...	...	...	...	...
2021Q1	0,04	0,28	-0,92	0,66	0,87	0,61	-0,78	0,65
2021Q2	0,15	0,32	-0,92	0,77	0,87	0,66	-0,79	0,70
2021Q3	0,20	0,38	-0,92	0,80	0,85	0,85	-0,79	0,88
2021Q4	1,00	1,00	-0,95	1,00	0,78	1,00	-1,00	1,00